Rocky Mountains
Southwest
Great Plains

Research Note RM-386

June 1980

USDA Forest Service
Rocky Mountain Forest and Range Experiment Station

Control of New Mexican Locust and the Effect on Planted Ponderosa Pine in Central Arizona

Gerald J. Gottfried[1]

Several herbicide applications were necessary to control New Mexican locust; however, first-year ponderosa pine seedling survival appeared to benefit from partial shade from locust sprouts which were not sprayed. In a separate study, soil moisture conditions in the top 24 inches (60 cm) were better in 5-year-old locust sites than in grass or 20-year-old locust sites. Managers may be able to manipulate the seral locust cover to speed pine regeneration.

Keywords: *Robinia neomexicana, Pinus ponderosa,* brush control, seedling survival

Many potentially good quality ponderosa pine[2] sites in Arizona and New Mexico are stocked with dense thickets of New Mexican locust (fig. 1), which impede conifer growth. New Mexican locust is a spiny shrub or small tree that grows in pure stands or as an understory species in ponderosa pine and mixed conifer stands between 4,000 and 8,500 feet (1,200 to 2,550 m) (Little 1950) in the Southwest (fig. 2). It is frequently found in association with Gambel oak. Locust sprouts readily and grows rapidly, especially after disturbances. It often competes with ponderosa pine and other conifer seedlings and saplings for moisture and light. Conifers eventually succeed locust, but it may take decades. Conifer planting could speed up the succession, but often this is not successful.

Locust control would reduce competition between the two species. Herbicides, possibly used in combination with prescribed burning or mechanical methods, may help

Figure 1.—New Mexican locust often forms dense, impenetrable stands after disturbances on ponderosa pine and lower mixed conifer sites (South Fork of Workman Creek). The area around this photo-point contains an average of 5,833 stems of locust and Gambel oak per acre. (14,408 stems per hectare).

[1]*Research Forester, Rocky Mountain Forest and Range Experiment Station. Headquarters is at Fort Collins, in cooperation with Colorado State University. Research was conducted at the Station' Research Work Unit at Tempe, in cooperation with Arizona State University.*

[2]*Common and scientific names of plants mentioned are listed in appendix.*

establish ponderosa pine plantations. Mechanical site preparation without herbicides is unsuccessful unless roots are ripped from the ground; otherwise, sprouts quickly reoccupy the site. The use of fire has not been tested. Since New Mexican locust sites often contain satisfactory residual pine, herbicides must be selective.

Some researchers (Ryker and Potter 1970, Youngberg 1966, Coffman 1975) indicate that brush may be beneficial to early conifer survival, especially where extreme environmental pressures exist. Youngberg (1966) concluded that moisture conditions were more favorable under brush canopies than in openings during initial seedling development. Many brush species also increase soil fertility by nitrogen-fixation and litter production. However, brush competition usually becomes a problem later.

Coffman (1975) found that several brush species, including locust, increased first-year survival of planted Douglas-fir in New Mexico. Little is known about ponderosa pine establishment in New Mexican locust sites. Although ponderosa pine is intolerant to shade, it is possible that locust may aid pine establishment, although it probably would have to be eliminated later.

Study Area

The exploratory studies reported here were conducted on the South Fork of Workman Creek within the Sierra Ancha Experimental Forest, about 30 miles (48 km) north of Globe, Ariz. Annual precipitation, measured at South Fork, has averaged (with standard error) 32.20 ± 9.61 inches (805 ± 240 mm) from 1956 to 1977, with two-thirds falling from October through May. Annual temperatures average 48° F (8.9° C), varying from 31° F (−0.6° C) in January to 65° F (18.3° C) during July and August.

Figure 2.--The range of New Mexican locust (Little 1976). The arrow indicates the approximate location of Workman Creek.

Dripping Springs quartzite, intruded by diabase and basalt, and Troy sandstone underlie the watersheds. Surface soils are loam to clay-loam texture, with granular or crumb structure. Subsoils are layered and vary from clay loam to clay. The studies were conducted on relatively level areas at about a 7,200-foot (2,160-m) elevation.

The original forest consisted of ponderosa pine with some Douglas-fir, white fir, and large Gambel oak. Average basal area was 201 square feet per acre (46.2 m^2 per ha). New Mexican locust and Gambel oak were common in the understory and produced a dense stand after a wildfire in 1957 burned 60 acres (24.3 ha), eliminating the overstory. Ground cover now consists of seeded slender and intermediate wheatgrass, brome, Kentucky bluegrass, and bracken fern and geranium. The locust cover was about 10 feet (3 m) tall when the studies began. Stem diameters, measured at 6 inches (15 cm) above the ground surface, averaged 1.25 inches (3.1 cm).

Methods

Locust Control and Ponderosa Pine Regeneration

Locust control and ponderosa pine regeneration studies used a randomized block design with three blocks and five treatments per block. Each plot was 25 by 25 feet (7.5 by 7.5 m). The study was established in April 1967.

The five locust control treatments were:[3]

Treatment 1.—Cut stems during dormant season (early April) and paint stumps with 2,4-D amine (dimethylamine salt of 2,4-dichlorophenoxyacetic acid). Spray sprouts with 2,4,5-T ester (isooctyl ester of 2,4,5-trichlorophenoxyacetic acid) at 2 pounds a.e. per acre (2.2 kg a.e. per ha) in an oil-water emulsion.

Treatment 2.—Cut stems during growing season (June); paint and spray as in treatment 1.

Treatment 3.—Spray foliage during growing season (June) with 2,4,5-Tester in water at 2 pounds a.e. per acre (2.2 kg a.e. per ha) and spray sprouts as in treatment 1.

Treatment 4.—Cut stems during dormant season, paint stumps, but only spray sprouts in September.

Treatment 5.—Cut stems during dormant season; no initial or sprout herbicide applications.

The treatments, applied according to the schedule in table 1, were generally scheduled to take advantage of management herbicide applications on Workman Creek. This is one reason why amitrole (3-amino-1,2,4-triazole) at 3.1 pounds a.i. per acre (3.5 kg a.i. per ha) was substituted for 2,4,5-T on two occasions. Cut stems were removed from plots. The initial herbicide application for treatment 3 was applied with a backpack mist blower; all other broadcast treatments were applied with truck-mounted, motorized,

[3]The study was conducted before the controversy about the safety of phenoxy herbicides such as 2,4,5-T. An emergency suspension was issued in March 1979 against the use of the herbicide on forest lands. A final decision has not been reached about the future registration of the herbicide.

Table 1.—Schedule of herbicide treatments applied to New Mexican locust

Treatment	1967 Apr.	1968 Jun.	1968 Sep.	1969 Jun.[1]	1969 Sep.	1970 Jun.[1]
1	X		X	X	X	X
2		X	X	X	X	X
3		X	X	X	X	X
4	X		X		X	
5	X					

[1]*Amitrole substituted for 2,4,5-T ester.*

high volume spray equipment. Foliage and stems were sprayed thoroughly to runoff.

The original treatment 5 plots (no herbicide) were inadvertently treated during an initial activity. New plots were established in an adjacent area which had similar precipitation, elevation, slope, and soils. History of the two sites was essentially similar. The relocation of treatment 5 compromises the randomized block design criteria, but it should not void the use of the model. Treatment effects were not compared with natural changes in an undisturbed locust stand. Stem counts were used to compare treatment effects.

Herbage production on each plot was determined by clipping randomly located 2-square-foot (0.18-m^2) subplots. Samples were oven-dried and weighed.

In March 1970, thirty-six 2-year-old ponderosa pine seedlings were planted in each of the 15 plots at a 5- by 5-foot (1.5- by 1.5-m) spacing. Because local seed was unavailable, trees were grown from seed collected at the same elevation in an adjacent tree seed-zone (Schubert and Pitcher 1973). The objective was to determine the effect of the pre- and post-planting herbicide applications on pine seedling survival. Seedlings were marked for future location and were checked periodically. Seedlings in very poor condition were counted as dead.

Soil Moisture

An unrelated study was established to determine if plant cover affected soil moisture through a growing season and if it would have implications for conifer regeneration. Gravimetric soil samples were collected by auger at approximately 2-week intervals from May 25 to October 5, 1976, from grass areas and from 5- and 20-year-old locust areas. Two sites which contained each of the three vegetation classes near each other were delineated in the main study area. Soil samples were taken in the spaces adjacent to grass plants and in the drip-line zone of the locust. Samples from locust sites were not collected from points with a heavy herbaceous layer. Three test holes were sampled from each vegetation type, in each site, for a total of 18 holes for every date. Four depths were sampled, 0-6 inches (0-15 cm), 6-12 inches (15-30 cm), 12-18 inches (30-45 cm), and 18-24 inches (45-60 cm). Soils were studied to 24 inches (60 cm), because ponderosa pine seedlings can grow a 20-inch (50-cm) tap root during the first season under optimum conditions (Schubert 1974). Standard bulk density measurements were made.

Results and Discussion

New Mexican Locust Control

The initial treatments in 1967 and 1968 were successful in eliminating the original brush overstory, but roots sprouted vigorously and some seeds germinated. The amount of sprouting was not significantly different among treatments. The average number of stems per plot increased from the original number of 58 ± 8 to 148 ± 18 prior to the September 1968 treatment.

Covariance analysis indicated significant changes ($p \leq 0.05$) when based on the pretreatment or the initial sprout locust stands. The five treatments can be divided into two groups based on the effectiveness of control. Individual comparisons between groups were significant; however, comparisons within groups generally were not.

Control at the end of the study (1971) was significantly better for the two dormant season stump treatments (1 and 4) and for the June foliage treatment (3), with an average of 14 ± 5 surviving stems per plot, than for the June stump treatment (2), and for the nonherbicide treatment (5), with an average of 79 ± 20 surviving stems per plot. This was true on either base. Differences were dramatic (fig. 3).

The two groups were also different after the September 1968 2,4,5-T application when based on the initial sprout stand. The average number of surviving stems per plot for treatments 1, 3, and 4 was reduced from 146 to 48 while the other treatments caused only slight changes. Control in 1971, based on the initial sprout stand, was slightly better in the dormant stump treatment which used both spring and fall sprout treatments (1) than in the dormant stump treatment which only used fall treatments (4) (a reduction from 104 to 9 surviving sprouts compared to a reduction from 202 to 19 sprouts). Although this indicates amitrole-related effects, 2,4,5-T appeared to produce better locust control.

The Spring 1970 inventory indicated significant differences between the nonherbicide treatment (5) (178 stems per plot) and treatments 1, 3, and 4 (average of 9 stems per plot) when based on pretreatment locust numbers. Fluctuations in treatment 5 results were caused by additional sprouting and natural mortality. High natural mortality has been reported for young black locust stands (Beck and McGee 1974), probably because locust is shade intolerant and suppressed sprouts do not survive long.

The initial 2,4,5-T treatment did not kill the locust root systems; however, they may have cumulatively contributed to the success of subsequent brush control. Bramble and Worley (1952) were able to eradicate black locust with a combination of a cut stub (stump) herbicide treatment and two annual foliage treatments. A combination of applications which did not include spraying the stubs was less effective. Bramble and Worley (1952) tested several herbicides including 2,4-D ester and 2,4,5-T ester. They also reported prolific sprouting after stub treatment.

The June stump treatment response was much different from the other spray treatments. Dormant season basal treatments of 2,4,5-T in oil (without cutting the stems) have proven effective against Gambel oak in Arizona (Johnson et al. 1969) and bear oak in Pennsylvania (Worley et al. 1957).

Dormant season applications were more effective than growing season applications in the latter experiment.

Foliage treatments might be preferred because they are easier to apply than are cut stump treatments. September applications of 2,4,5-T would be better than similar June treatments where ponderosa pine has already become established. Gratkowski (1977) reports that the pine is susceptible to 2,4,5-T damage in June but not in late August and September. This has also been observed at Workman Creek following management herbicide activities.

Cut stump treatments could be used on small areas or for spot applications. Use on larger areas would require heavy mechanical equipment (e.g., a bulldozer with a mounted spray rig). Such equipment can be directed to avoid areas with acceptable pine stocking.

Ponderosa Pine Regeneration

Ponderosa pine seedlings were checked in April and May 1970, but no survival differences among plots were found. Survival dropped from 66% in May to an unsatisfactory 21% in July, the main drought period in the Southwest. Analysis of July data indicated significantly better survival (39%) in the undisturbed locust sprout plots (treatment 5) than in two of the herbicide treatment plots (2 and 4) (12%). By October, overall ponderosa pine survival for all treatments was 9%; however, survival was significantly greater in treatment 5 (24%) than in the other four treatments (5%).

Pine mortality appeared to be almost equally caused by drought and by pocket gophers (*Thomomys bottae*). Herbage production which would affect soil moisture availability for seedlings was similar for all treatments and averaged 1,000 ± 104 pounds per acre (1,120 ± 117 kg per ha). Ideally, this heavy cover should have also been controlled. Gopher damage was not significantly different among treatments.

Some amitrole damage to pine seedlings in the form of chlorotic pine needles was observed from the 1970 treatment, but a subsequent check did not indicate mortality.

Ponderosa pine survival was poor, and the site would have to be replanted under normal management. However, tree survival in treatment 5 (no sprout control) was comparatively good. It appears that seedling survival could be related to the locust and oak cover which affected seedling microclimate. However, the degree of shade is very important, especially for a shade-intolerant species. Seedlings growing in partial shade apparently do best, but too much shade is detrimental. Pearson (1950) found that more than 50% artificial overhead shade affected ponderosa pine survival. Overhead shade is more detrimental than side shade (Pearson 1950). On severe sites, some protection may improve initial survival. Shade may be particularly critical for newly planted seedlings, because they usually only have 30 to 45 days to adjust to the field before the late spring drought. The apparent benefits of brush cover were also observed in 1973 on South Fork, where 2-year-old ponderosa pine seedlings survived better in the partial shade of locust sprouts than in adjacent openings. Any measures which enhance seedling survival during the critical early years will improve the chances of achieving adequate stocking.

It is always best to establish ponderosa pine as soon as possible after a disturbance. Managers should take advantage of the temporary benefits of a partial locust cover by delaying brush control until the locust impedes pine development. An environmentally safe herbicide, which would not injure conifers, would provide such an option. Since the environmental safety of 2,4,5-T and other herbicides has recently been questioned, alternative herbicides need to be tested and registered before control recommendations can be made.

a

b

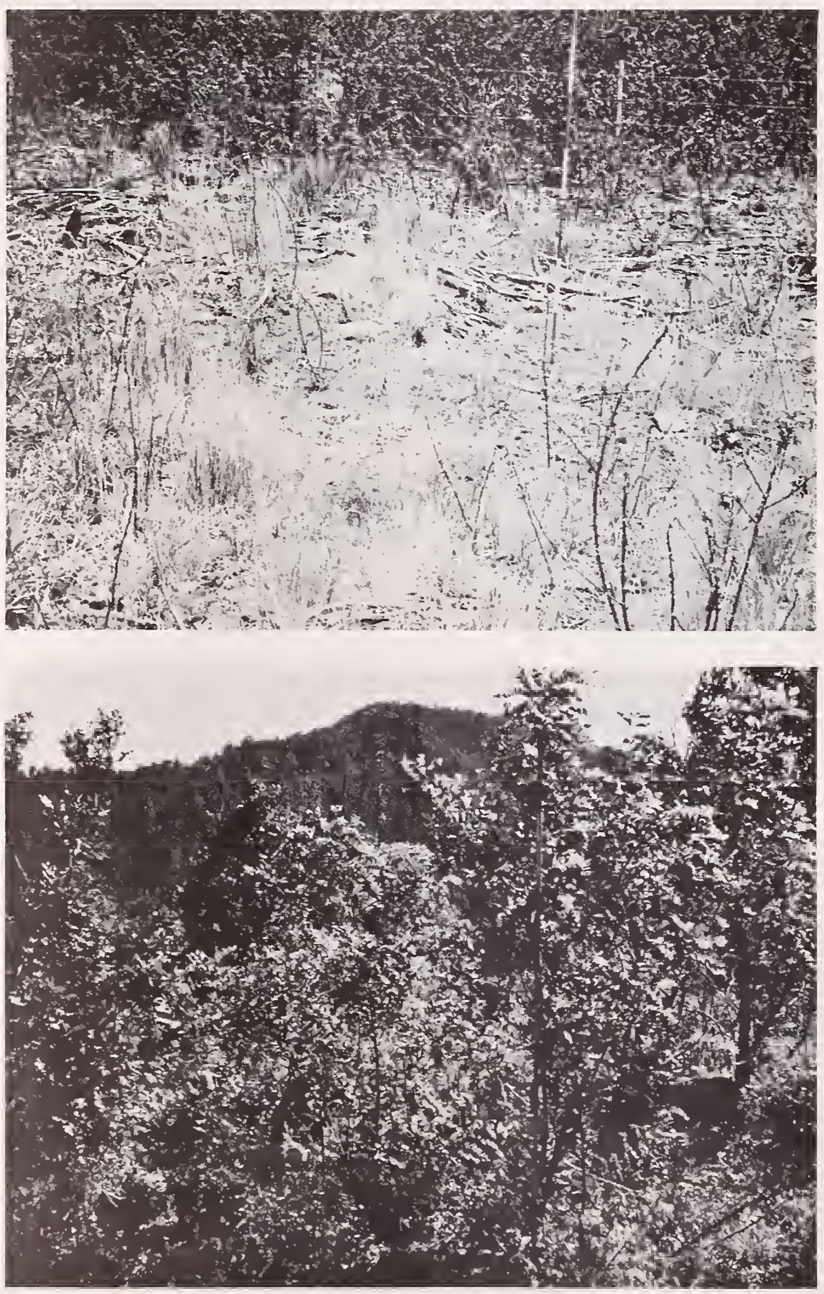

Figure 3.—A photographic comparison in June 1971 of (a) a typical plot where locust has been controlled, with (b) a nonherbicide plot. The range pole is 8 feet (2.4 m) tall.

Soil Moisture

The results of this study cannot be used to explain the previous findings because of the time gap. The study showed significantly more moisture in the top 24 inches (60 cm) of soil under 5-year-old locust stands than in the grass stands (fig. 4). The differences between 5- and 20-year-old locust stands were significant 8 out of the 10 dates. Grass and 20-year-old locust stands had different soil moisture on seven dates. Soil moisture was generally greatest in the 5-year-old stands, intermediate in the grass, and lowest in the 20-year-old stands. Some exceptions to this ranking may be a result of sampling variation.

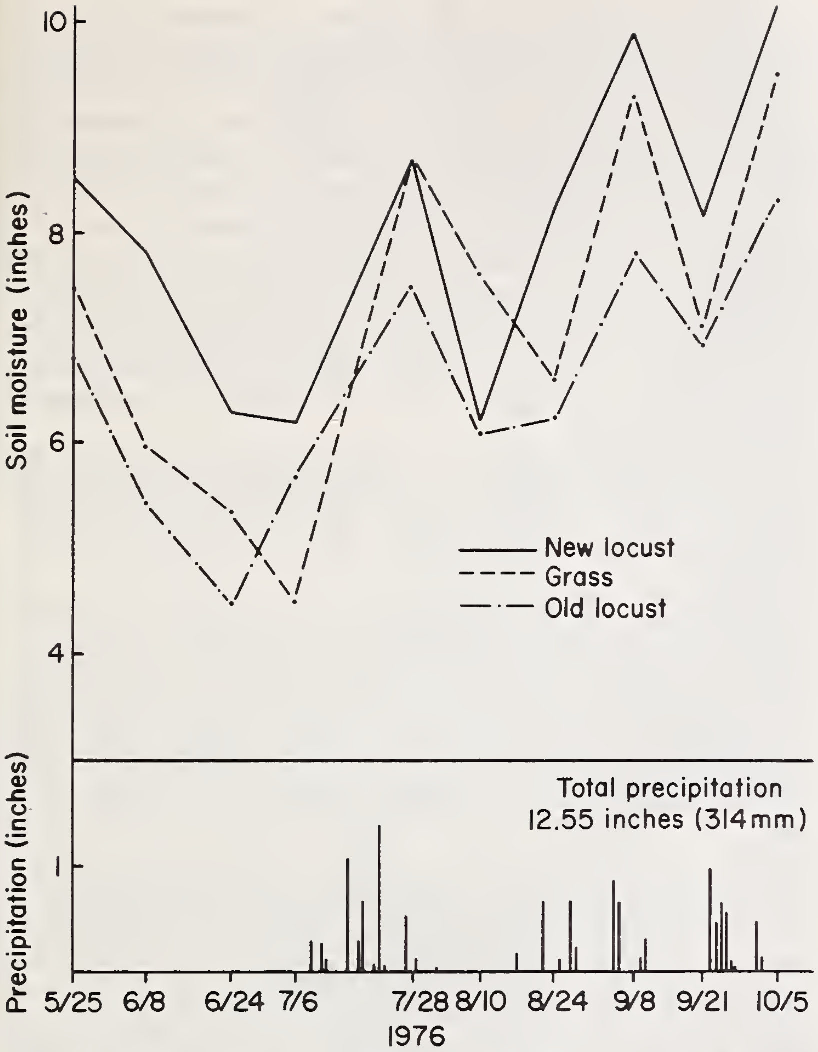

Figure 4.—Changes in moisture in the top 24 inches (60 cm) of soil under new locust, grass, and old locust. South Fork precipitation is shown at the bottom; 24.62 inches (616 mm) fell between October 1975 and May 1976.

Soil moisture for the area varied by depth during most of the season. The 0- to 6-inch depth had less soil moisture than the three lower depths, except after rain, when conditions were similar to the 6- to 12-inch depth. The 6- to 12-inch depth usually had less moisture than the two lowest depths, which were generally equal. All three vegetation types showed this relationship among depths.

More intensive research is necessary before any definite recommendations can be made. However, the additional soil moisture adjacent to young locust would benefit conifer regeneration. An understanding of the optimum spacing between locust and ponderosa pine is needed. Such information could be used to prepare guidelines for determining when control should be started and where conifer seedlings could be planted so that they would receive protection, especially when dead shade (i.e., logs) is not available.

Literature Cited

Beck, Donald E., and Charles E. McGee. 1974. Locust sprouts reduce growth on yellow-poplar seedlings. USDA Forest Service Research Note SE-101, 6 p. Southeastern Forest Experiment Station, Asheville, N.C.

Bramble, W. C., and D. P. Worley. 1952. Control of black locust with chemical sprays. Pennsylvania State College Progress Report 72, 5 p.

Coffman, Michael S. 1975. Shade from brush increases survival of planted Douglas-fir. Journal of Forestry 73:726-728.

Gratkowski, H. J. 1977. Seasonal effects of phenoxy herbicides on ponderosa pine and associated brush species. Forest Science 23:2-12.

Johnsen, Thomas N., Warren P. Clary, and Peter F. Ffolliott. 1969. Gambel oak control on the Beaver Creek pilot watershed in Arizona. U.S. Department of Agriculture, Agricultural Research Service, ARS-34-104, 8 p.

Little, Elbert L., Jr. 1950. Southwestern trees. U.S. Department of Agriculture, Agriculture Handbook 9, 109 p. Washington, D.C.

Little, Elbert L., Jr. 1976. Atlas of United States trees. Volume 3: Minor western hardwoods. USDA Forest Service Miscellaneous Publication 1314, 230 p. Washington, D.C.

Pearson, G.A. 1950. Management of ponderosa pine in the Southwest. U.S. Department of Agriculture, Agriculture Monograph 6, 218 p. Washington, D.C.

Ryker, Russell A., and Dale R. Potter. 1970. Shade increases first-year survival of Douglas-fir seedlings. USDA Forest Service Research Note INT-119, 6 p. Intermountain Forest and Range Experiment Station, Ogden, Utah.

Schubert, Gilbert H. 1974. Silviculture of southwestern ponderosa pine: The status of our knowledge. USDA Forest Service Research Paper RM-123, 71 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

Schubert, Gilbert H., and John A. Pitcher. 1973. A provisional tree seed-zone and cone-crop rating system for Arizona and New Mexico. USDA Forest Service Research Paper RM-105, 8 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

Worley, D. P., W. C. Bramble, and W. R. Byrnes. 1957. Investigation of the use of 2,4,5-T esters as a basal spray in the control of bear oak. Weeds 5:121-132.

Youngberg, C. T. 1966. Silvicultural benefits from brush. Proceedings of the Society of American Foresters 1965:55-59.

Appendix

Common and Scientific Names of Plants

Bear oak	*Quercus ilicifolia* Wang.
Black locust	*Robinia pseudoacacia* L.
Bracken fern	*Pteridium aquilinum* var. *pubescens* Underw.
Brome	*Bromus* spp.
Douglas-fir (Rocky Mountain)	*Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco
Gambel oak	*Quercus gambelii* Nutt.
Geranium	*Geranium eremophilum* Woot. & Standl.
Intermediate wheatgrass	*Agropyron intermedium* (Host) Beaver.
Kentucky bluegrass	*Poa pratensis* L.
New Mexican locust	*Robinia neomexicana* A. Gray
Ponderosa pine	*Pinus ponderosa* Laws.
Slender wheatgrass	*Agropyron trachycaulum* (Link) Stend.
White fir	*Abies concolor* (Gord. & Glend.) Lindl.

Agriculture—CSU, Fort Collins